

**GARMIII/Biological Reference Point
Pollock in SA 5&6**

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1.0 Background

Pollock, *Pollachius virens* (L.) have traditionally been assessed as a unit stock from the Scotian Shelf (NAFO Divisions 4VWX) to Georges Bank, the Gulf of Maine and portions of the Mid-Atlantic region (Subareas 5 and 6). This stock was last assessed over its range *via* VPA at SAW 16 in 1993 (Mayo and Figuerido 1993, NEFSC 1993a, 1993b). At that time, spawning stock biomass had been declining since the mid-1980s, and was expected to reach its long-term average (144,000 mt). Fishing mortality was estimated to be 0.72 in 1992, above F20% (0.65) and well above Fmed (0.47). The stock was then considered to be fully exploited and at a medium biomass level.

The state of this stock was first evaluated *via* index assessment in 2000 (Mayo 2001). At that time, it was noted that biomass indices for the Gulf of Maine-Georges Bank portion of the stock, derived from NEFSC autumn bottom trawl surveys, had increased during the mid-1970s, declined sharply during the 1980s, but have been generally increasing since the mid-1990s. Indices derived from Canadian bottom trawl surveys, conducted on the Scotian Shelf, increased during the 1980s, but declined sharply during the early 1990s. The index assessment provided no basis with which to evaluate the state of the stock relative to the control rule as determined by the Overfishing Definition Review Panel (Anon. 1998).

In 2002, index-based biological reference points were developed for a portion of the pollock stock primarily under US management jurisdiction (Subareas 5 and 6), including a portion of eastern Georges Bank (Subdivision 5Zc) that is under Canadian management jurisdiction (NEFSC 2002). The most recent assessment of the resource inhabiting the area comprising this management unit was conducted in August, 2005 at the Second Groundfish Assessment Review Meeting (GARM II) (NEFSC 2005). At that time it was determined that the index of current biomass was greater than ½ of the Bmsy proxy reference point and that the index of current F was below the Fmsy proxy reference point (Mayo et al. 2005).

2.0 The Fishery

Since 1984, the USA fishery has been restricted to areas of the Gulf of Maine and Georges Bank west of the line delimiting the USA and Canadian fishery zones. The Canadian fishery occurs primarily on the Scotian Shelf and additional landings are obtained from Georges Bank east of the line delimiting the USA and Canadian fishery zones. This fishery on the Scotian Shelf has shifted westward over time, and the contribution to the total catch from larger, mobile gear vessels has steadily diminished since 1981.

The commercial fishery in Subareas 5&6 is dominated by United States vessels; additional catches are taken by Canada and, for a period primarily during the 1970s, by some distant water fleets. The total landings increased steadily from less than 10,000 mt during the 1960s to a maximum of over 26,000 mt in 1986 (Figure M1). Landings declined sharply during the late 1980s and have remained below 10,000 mt throughout most of the 1990s. Landings since 1994 have fluctuated between 4,420 and 9,346 mt.

Annual catches of pollock from the recreational fishery in Subareas 5&6, excluding those caught and released alive, have fluctuated between 100 and 1,000 mt. In most years the total catch remained below 400 mt.

Commercial landings: Commercial landings from the USA portion of the fishery in SA 5&6 were updated through 2006 (Table M1, Figure M1). Revised Canadian landings from Divs. 5Y and 5Z were also included through 2006. There was no need to apply the preferred allocation scheme reviewed at the GARMIII Data Meeting, October, 2007.

Commercial Biological Samples: Length and age samples continue to be collected from the USA and Canadian fisheries. For this assessment of the SA5&6 portion of the stock, length and age data have not been utilized since the 1992 assessment of the entire Divs 4VWX and SA 5&6 stock (Mayo and Figuerido 1993, NEFSC 1993a, 1993b) as noted in Section M2 below.

Commercial Discards: The extent of discarding in the commercial fishery has not been investigated to date.

Recreational Landings: USA Recreational landings are available in the MRFSS database (Table M2), and have been included in one formulation of this assessment.

3.0 Research Survey Indices

Indices of relative biomass (ln re-transformed), derived from NEFSC autumn research vessel bottom trawl surveys covering Georges Bank and the Gulf of Maine have varied considerably since 1963 (Table M2, Figure M2). Indices generally fluctuated between 2 and 5 kg per tow throughout most of the 1960s and 1970s, peaking at over 8 kg per tow during the mid-to-late 1970s, reflecting recruitment of several moderate-to strong year classes from the early 1970s. Biomass indices declined rapidly during the early 1980s, and continued to decline steadily through the early 1990s, remaining below 1 kg per tow and reaching a minimum during the mid-1990s. Since then, biomass indices from the Gulf of Maine-Georges Bank region have generally increased, reaching 1.5 kg per tow in 1999 and have recently been fluctuating between 2 and 2.5 kg/tow (Table M3, Figure M2). The most recent biomass indices declined below 1.0 in 2006 and 2007.

4.0 Assessment Results

As evident from recent trends in total landings from Subareas 5 and 6 and NEFSC autumn biomass indices calculated for the Gulf of Maine-Georges Bank region, relative F_s (landings/NEFSC autumn biomass index) peaked in the mid-to-late 1980s after which they steadily declined (Table M4 Figure M3). Biomass indices from the Gulf of Maine-Georges Bank region have been increasing throughout the late 1990s and now indicate that biomass may have returned to levels evident during the early 1980s.

Relative Exploitation Rate and Replacement Ratio Analyses

An index of relative exploitation (catch/survey biomass index) corresponding to a replacement ratio of 1.0 was developed by the Working Group on Re-Evaluation of Biological Reference Points for New England Groundfish (NEFSC 2002) for the portion of the unit stock of pollock in NAFO Subareas 5&6 based on the AIM (An Index Method) model. This model was employed again for the present assessment Autumn NEFSC survey biomass indices from the Gulf of Maine and Georges Bank region from 1963 through 2006 were used to calculate the replacement ratios, defined as the biomass index in the current year divided by the average biomass indices from the previous 5 years.

Survey biomass indices and total landings were used to compute the relative exploitation rates, defined as the catch in the current year divided by the 3 year average survey biomass index for the current year and the previous and following years. These relative exploitation rates (or relative F) may be considered a proxy for F on that portion of the pollock stock considered in this analysis. The relationship between replacement ratios and relative F was evaluated by a linear regression of the Log_e replacement ratio on Log_e relative F and the results were used to derive an estimate of relative F corresponding to a replacement ratio of 1.0. A complete description of the AIM model can be found in NEFSC (2002).

Two analyses were performed. Only commercial landings were included in the first analysis to be consistent with the analysis performed in 2002 (NEFSC 2002). The second analysis included recreational harvest estimates since 1981. Both analyses provided similar results as illustrated in Table M5. The correlation between relative F and replacement ratios for pollock were significant in both analyses ($P=0.04$).

The replacement relative F based on commercial landings alone equaled 5.637 while the estimate based on commercial and recreational landings equaled 5.758. The information provided in Table M4 and Figures M1 through M4 is based on the second analysis which included commercial and recreational harvest.

Trends in 3 year average relative F (exploitation ratio) and replacement ratios are given in Figures M3 and M4, respectively and the values are listed in Table M4. Prior to the 1980s, a high proportion of the replacement ratios equaled or exceeded 1.0 (Figure M4). During the 1980s and early 1990s, most of the replacement ratios were less than 1.0, with ratios greater than 1.0 appearing again by the late 1990s as the biomass indices began to gradually increase from the very low levels of the mid-1990s.

The information displayed in these figures also provides a means to derive a biomass index which relates to the replacement ratios. In this case, it is evident that most of the replacement ratios below 1.0 occurred during the 1980s when the biomass index was less than about 3.0 (Figure M2). It is also evident that all of the biomass indices during this period were below 2.0. This could serve as a revised Bmsy proxy for this stock. During this period the relative Fs were also well above the relative replacement F (Figure M5). This biomass index may be considered as the biomass proxy for Bmsy that corresponds to the relative F proxy for Fmsy. This value remains unchanged in the present assessment compared to the value obtained in 2002 (NEFSC 2002).

5.0 Biological Reference Points

The biological reference points first developed by the Working Group on Re-Evaluation of Biological Reference Points for New England Groundfish (NEFSC 2002) are:

B_{msy} 3.00 kg/tow
F_{msy} 5.88 (Relative F)
MSY 17,640 mt

Since the relative F relates the catch directly to survey biomass, the catch corresponding to the B_{msy} proxy can be estimated by multiplying the relative F and the biomass index of B_{msy}. The following biological reference point proxies were obtained from the index-based AIM model that included commercial landings alone using the existing B_{msy} value and a revised B_{msy} value.

<u>Existing Bmsy</u>	<u>Revised Bmsy</u>
B _{msy} 3.00 kg/tow	B _{msy} 2.00 kg/tow
F _{msy} 5.637 (Relative F)	F _{msy} 5.637
MSY 16,911 mt	MSY 11,274 mt

The following biological reference point proxies were obtained from the index-based AIM model that included commercial and recreational landings for 2 B_{msy} values.

<u>Existing Bmsy</u>	<u>Revised Bmsy</u>
B _{msy} 3.00 kg/tow	B _{msy} 2.00 kg/tow
F _{msy} 5.758 (Relative F)	F _{msy} 5.758 (Relative F)
MSY 17,274 mt	MSY 11,516 mt

6.0 Summary

Since the mid-1990s, the NEFSC autumn survey biomass had been increasing towards the current 3.0 kg/tow B_{msy} proxy. However, the biomass index declined substantially in 2006 and 2007 below 1.0 kg/tow. Since 1999, the relative F has remained below the F_{msy} proxy and the replacement ratio has remained at or above 1.0

7.0 GARMIII Model Selection Meeting Panel Comments

One panel member suggested that age composition information may provide insight into recruitment pattern for this stock. While commercial catch at age has not been calculated since the early 1990s, the age composition of the survey catch/tow indices (Appendix 1) may address this comment

On first glance, it is clear from both seasons that the age structure has been truncated to a large extent, especially in the autumn survey. Large year effects tend to cloud the progression of

cohorts over time (e.g., 1985 spring, 1988 autumn

8.0 References

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Table M1. Commercial landings (mt) of pollock from SA5&6 by USA, Canadian and DWF fleets.

Pollock with TOTAL SA 5&6 Landings				Total includes CDN, DWF and USA			
Year	Autumn Biom Index	Total 5&6 Landings(mt)	000s mt	USA 5&6 Landings	Other 5&6 Landings	USA 5&6 Percent	Other 5&6 Percent
1960		10397	10.397	8186	2211	78.7	21.3
1961		8219	8.219	7861	358	95.6	4.4
1962		6151	6.151	5550	601	90.2	9.8
1963	4.939	6241	6.241	4673	1568	74.9	25.1
1964	2.716	9008	9.008	4768	4240	52.9	47.1
1965	2.362	9000	9.000	4916	4084	54.6	45.4
1966	1.795	9847	9.847	3171	6676	32.2	67.8
1967	1.310	8534	8.534	2784	5750	32.6	67.4
1968	2.654	5222	5.222	2981	2241	57.1	42.9
1969	3.424	9822	9.822	3507	6315	35.7	64.3
1970	1.699	11976	11.976	3592	8384	30.0	70.0
1971	2.189	15203	15.203	4732	10471	31.1	68.9
1972	3.279	13013	13.013	5243	7770	40.3	59.7
1973	4.037	13076	13.076	5731	7345	43.8	56.2
1974	1.542	12393	12.393	8050	4343	65.0	35.0
1975	1.494	13871	13.871	8577	5294	61.8	38.2
1976	8.567	13382	13.382	10244	3138	76.6	23.4
1977	5.628	16273	16.273	12729	3544	78.2	21.8
1978	3.862	22305	22.305	17545	4760	78.7	21.3
1979	4.074	18452	18.452	15420	3032	83.6	16.4
1980	2.647	23539	23.539	17905	5634	76.1	23.9
1981	1.083	22068	22.068	18018	4050	81.6	18.4
1982	1.364	19466	19.466	14092	5374	72.4	27.6
1983	1.274	17816	17.816	13433	4383	75.4	24.6
1984	0.564	20633	20.633	17343	3290	84.1	15.9
1985	1.742	21069	21.069	19305	1764	91.6	8.4
1986	1.089	26507	26.507	24316	2191	91.7	8.3
1987	1.223	23467	23.467	20251	3216	86.3	13.7
1988	1.787	17648	17.648	14900	2748	84.4	15.6
1989	0.619	12434	12.434	10518	1916	84.6	15.4
1990	0.994	11518	11.518	9432	2086	81.9	18.1
1991	0.649	10053	10.053	7882	2171	78.4	21.6
1992	0.910	10671	10.671	7192	3479	67.4	32.6
1993	0.505	10238	10.238	5676	4562	55.4	44.6
1994	0.328	7332	7.332	3769	3563	51.4	48.6
1995	0.504	4611	4.611	3358	1253	72.8	27.2
1996	0.654	4420	4.420	2963	1457	67.0	33.0
1997	1.003	5794	5.794	4252	1542	73.4	26.6
1998	0.772	7865	7.865	5583	2282	71.0	29.0
1999	1.532	5726	5.726	4595	1131	80.2	19.8
2000	0.844	5376	5.376	4043	1333	75.2	24.8
2001	2.448	5784	5.784	4111	1673	71.1	28.9

2002	1.855	5354	5.354	3580	1774	66.9	33.1
2003	2.197	6735	6.735	4794	1941	71.2	28.8
2004	1.925	7245	7.245	5061	2184	69.9	30.1
2005	2.533	9346	9.346	7498	1848	80.2	19.8
2006	0.959	7043	7.043	6067	976	86.1	13.9
2007	0.754				647		

Table M2. Recreational catch of pollock from SA5&6.

Total Catch of Pollock (Including Released Alive)				Retained Catch of Pollock (Excluding Released Alive)				
Year	Numbers (000s)	SE	Weight (mt)	Numbers (000s)	SE	Weight (mt)	SE	AB1 Avg Wgt (kg)
1981	2226.624	12.2	1158.963	1444.987	13.3	752.119	13.5	0.520502
1982	1539.039	16.9	1573.219	800.907	15	818.694	15.5	1.022209
1983	971.096	18.4	1313.407	429.476	20	580.866	20	1.352499
1984	508.016	22.2	179.5818	324.49	32.1	114.706	32.1	0.353496
1985	1491.151	35.2	317.1506	1217.767	42.5	259.005	42.8	0.212688
1986	522.937	20.2	177.1421	421.769	24	142.872	24.6	0.338745
1987	670.942	22.5	302.8073	255.847	19.8	115.468	20.3	0.451317
1988	1266.767	47.5	572.7964	369.793	19.2	167.21	19.9	0.452172
1989	602.586	18.1	495.5234	315.064	17.1	259.086	16.1	0.822328
1990	352.358	19	270.9374	201.94	30.9	155.277	31.6	0.768926
1991	440.764	35.9	389.2567	113.179	17.6	99.953	18.8	0.883141
1992	167.569	15.3	96.78733	85.738	21.2	49.522	22.7	0.577597
1993	396.704	15.3	109.7715	187.381	19.1	51.85	20.2	0.276709
1994	861.982	20.2	455.0012	479.202	29.2	252.949	29.5	0.527855
1995	806.888	28.4	760.9678	261.394	31.8	246.518	32	0.94309
1996	464.625	18.2	562.4352	280.171	25.3	339.151	25.6	1.210514
1997	284.892	17	368.364	151.825	28.9	196.309	29	1.292995
1998	452.361	10.3	314.1495	184.906	17.7	128.411	17.8	0.694466
1999	562.123	13.5	230.3734	217.516	26.4	89.144	26.4	0.409827
2000	1075.624	9.7	976.4788	436.617	15.9	396.372	15.9	0.907825
2001	1058.024	7.6	1920.753	355.713	11.6	645.767	11.6	1.815416
2002	496.294	14.4	791.9331	239.175	15.8	381.65	15.8	1.595694
2003	356.07	15.2	210.058	158.465	17.2	93.484	17.2	0.589935
2004	307.629	13.7	354.2347	223.697	16.8	257.587	16.8	1.1515
2005	254.132	12.5	533.5437	156.804	13.8	329.206	13.8	2.099475
2006	278.236	15	551.5738	175.068	20.8	347.054	20.9	1.982395

Table M3. Stratified mean catch per tow in weight (kg) and numbers for Scotian Shelf, Gulf of Maine, and Georges Bank pollock in NEFSC offshore spring and autumn bottom trawl surveys¹, 1963-2007³. Indices for the total stock and the mature component are listed.

	NEFSC Spring Survey ²								NEFSC Autumn Survey							
	Total Biomass		Mature Biomass		Total Numbers		Mature Numbers		Total Biomass		Mature Biomass		Total Numbers		Mature Numbers	
	Linear	Re-trans	Linear	Re-trans	Linear	Re-trans	Linear	Re-trans	Linear	Re-trans	Linear	Re-trans	Linear	Re-trans	Linear	Re-trans
1963	-	-	-	-	-	-	-	-	5.502	4.939	5.164	4.636	1.401	1.289	1.113	1.024
1964	-	-	-	-	-	-	-	-	4.755	2.716	4.092	2.337	1.770	1.136	0.975	0.626
1965	-	-	-	-	-	-	-	-	2.977	2.362	2.657	2.108	0.903	0.847	0.555	0.521
1966	-	-	-	-	-	-	-	-	2.567	1.795	2.003	1.401	1.060	0.637	0.488	0.293
1967	-	-	-	-	-	-	-	-	1.973	1.310	1.809	1.201	0.560	0.478	0.391	0.334
1968	4.537	2.876	4.292	2.721	1.121	0.932	0.677	0.563	3.494	2.654	3.343	2.539	0.758	0.696	0.569	0.522
1969	2.723	2.584	2.404	2.281	1.157	1.014	0.519	0.455	7.208	3.424	6.994	3.322	1.395	0.884	1.248	0.791
1970	5.295	3.920	4.928	3.648	1.659	1.449	0.994	0.868	2.251	1.699	2.082	1.571	0.609	0.588	0.377	0.364
1971	3.474	2.831	3.266	2.661	0.973	0.897	0.593	0.547	4.365	2.189	3.833	1.922	1.201	0.778	0.612	0.396
1972	5.003	3.618	4.051	2.930	3.871	2.140	0.867	0.479	4.589	3.279	4.079	2.915	1.448	1.174	0.733	0.594
1973	4.927	3.835	3.508	2.731	4.329	1.710	1.018	0.402	4.683	4.037	4.382	3.778	1.267	1.106	0.865	0.755
1974	3.951	4.157	3.553	3.738	1.344	1.176	0.755	0.661	3.332	1.542	2.912	1.348	0.953	0.576	0.654	0.395
1975	5.919	5.580	5.409	5.099	1.621	1.298	1.014	0.812	2.087	1.494	1.905	1.364	0.718	0.493	0.381	0.262
1976	7.204	7.490	6.798	7.068	1.612	1.483	1.227	1.129	18.261	8.567	17.406	8.166	4.038	1.895	3.674	1.724
1977	3.591	3.295	3.205	2.941	1.717	1.318	0.882	0.677	9.376	5.628	8.789	5.276	2.272	1.303	1.739	0.997
1978	5.130	3.107	4.272	2.587	1.898	0.835	1.091	0.480	6.275	3.862	6.033	3.713	1.064	0.723	0.790	0.537
1979	4.585	3.750	4.348	3.556	1.036	0.939	0.785	0.712	4.770	4.074	4.504	3.847	0.865	0.719	0.718	0.597
1980	4.191	3.531	3.711	3.127	1.451	1.069	0.987	0.727	3.298	2.647	3.202	2.570	0.580	0.544	0.470	0.441
1981	5.749	5.391	5.415	5.078	1.395	1.221	0.989	0.866	2.683	1.083	2.178	0.879	1.033	0.341	0.672	0.222
1982	6.372	3.349	5.839	3.069	3.755	1.767	2.076	0.977	2.118	1.364	1.966	1.266	0.759	0.574	0.493	0.373
1983	1.592	1.018	1.533	0.980	0.897	0.662	0.251	0.185	2.989	1.274	2.834	1.208	0.976	0.579	0.479	0.284
1984	3.119	2.298	3.002	2.212	1.084	0.914	0.688	0.580	0.909	0.564	0.778	0.483	0.421	0.367	0.188	0.164
1985	29.132	8.446	26.404	7.655	14.587	2.725	12.014	2.244	2.114	1.742	1.875	1.545	1.080	0.708	0.454	0.298
1986	8.256	4.283	8.123	4.214	1.973	1.333	1.686	1.139	1.707	1.089	1.466	0.935	0.898	0.571	0.528	0.336
1987	2.778	1.870	2.510	1.690	1.616	0.738	0.599	0.274	2.035	1.223	1.924	1.156	0.597	0.506	0.383	0.325
1988	2.015	1.384	1.950	1.339	0.907	0.758	0.339	0.283	13.021	1.787	12.088	1.659	3.754	0.869	3.131	0.725
1989	5.216	2.156	5.041	2.084	1.998	1.024	1.577	0.808	1.223	0.619	0.723	0.366	1.883	0.771	0.461	0.189
1990	1.821	1.165	1.675	1.072	0.760	0.560	0.442	0.326	2.079	0.994	1.888	0.903	0.823	0.586	0.502	0.357
1991	5.051	2.797	4.738	2.624	2.303	1.399	1.762	1.070	1.055	0.649	0.851	0.524	0.728	0.535	0.409	0.301
1992	3.349	2.166	3.139	2.030	1.787	1.242	0.755	0.525	1.697	0.910	1.507	0.808	1.051	0.643	0.520	0.318
1993	1.602	1.248	1.358	1.058	1.648	1.163	0.534	0.377	0.769	0.505	0.570	0.374	1.043	0.567	0.195	0.106
1994	1.065	0.840	0.972	0.767	0.562	0.504	0.380	0.341	0.603	0.328	0.500	0.272	0.422	0.311	0.270	0.199
1995	3.716	1.307	2.659	0.935	3.432	0.820	1.984	0.474	1.017	0.504	0.787	0.390	0.840	0.465	0.516	0.286
1996	1.080	0.758	1.023	0.718	0.650	0.510	0.342	0.268	1.060	0.654	0.862	0.532	1.009	0.666	0.435	0.287
1997	4.573	2.060	3.866	1.742	3.369	1.802	1.693	0.906	1.512	1.003	1.095	0.726	1.766	0.921	0.611	0.319
1998	2.643	1.564	2.139	1.266	2.609	1.506	0.900	0.520	1.308	0.772	0.860	0.508	2.104	0.748	0.539	0.192
1999	1.069	0.862	0.745	0.601	2.165	1.022	0.419	0.198	3.099	1.532	2.595	1.283	2.414	1.394	1.161	0.670
2000	1.369	0.997	1.222	0.890	1.502	0.973	0.434	0.281	1.441	0.844	0.522	0.306	2.770	1.333	0.583	0.278
2001	2.029	1.275	1.854	1.165	1.693	1.272	0.728	0.547	3.567	2.448	3.067	2.105	2.385	1.811	1.361	1.033
2002	1.578	1.247	1.475	1.166	0.760	0.630	0.482	0.400	5.920	1.855	5.420	1.698	3.135	1.460	2.305	1.073
2003	0.890	0.667	0.731	0.548	1.439	0.734	0.242	0.123	7.951	2.197	6.348	1.754	7.363	2.043	4.790	1.329
2004	0.744	0.585	0.703	0.553	0.487	0.380	0.180	0.140	4.206	1.925	3.440	1.574	3.221	1.395	2.122	0.919
2005	5.620	2.377	5.459	2.305	2.016	1.235	1.588	0.973	7.415	2.533	6.507	2.223	4.769	1.636	2.700	0.926
2006	2.589	1.493	2.534	1.467	0.972	0.758	0.766	0.597	1.856	0.959	1.578	0.815	1.591	0.568	0.574	0.205
2007	4.671	2.655	4.466	2.538	1.988	1.423	1.425	0.805	1.394	0.754	1.314	0.711	0.607	0.438	0.404	0.292

¹ NEFSC Strata 01130-01300, 01330-01340, 01360-01400.

² The "36 Yankee" trawl was used from 1970-1972, and 1982-2002; the "41 Yankee" trawl was used from 1973-1981.

No gear conversion factors are available to adjust for differences in fishing power.

³ BMV oval doors were used from 1970-1984; since 1985 Portuguese polyvalent doors have been used. No door conversion factors were applied. Surveys performed using *R/V Albatross IV* and *R/V Delaware II*; No vessel conversion factors were applied.

Table M4. Assessment measures used to evaluate the SA 5&6 component of the pollock stock
Landings include recreational harvest.

Year	Autumn Kg/tow	Landings (mt)	Landings (000s mt)	Exploitation Ratio	Replacement Ratio
1963	4.939	6241	6.241	1.631	
1964	2.716	9008	9.008	2.698	
1965	2.362	9000	9.000	3.928	
1966	1.795	9847	9.847	5.404	
1967	1.310	8534	8.534	4.446	
1968	2.654	5222	5.222	2.120	1.011
1969	3.424	9822	9.822	3.789	1.580
1970	1.699	11976	11.976	4.914	0.736
1971	2.189	15203	15.203	6.364	1.006
1972	3.279	13013	13.013	4.107	1.454
1973	4.037	13076	13.076	4.429	1.524
1974	1.542	12393	12.393	5.256	0.527
1975	1.494	13871	13.871	3.586	0.586
1976	8.567	13382	13.382	2.559	3.416
1977	5.628	16273	16.273	2.704	1.487
1978	3.862	22305	22.305	4.933	0.908
1979	4.074	18452	18.452	5.231	0.966
1980	2.647	23539	23.539	9.049	0.560
1981	1.083	22820	22.820	13.439	0.219
1982	1.364	20285	20.285	16.354	0.394
1983	1.274	18397	18.397	17.236	0.489
1984	0.564	20748	20.748	17.387	0.270
1985	1.742	21328	21.328	18.847	1.256
1986	1.089	26650	26.650	19.721	0.903
1987	1.223	23583	23.583	17.260	1.014
1988	1.787	17815	17.815	14.727	1.516
1989	0.619	12693	12.693	11.200	0.483
1990	0.994	11674	11.674	15.483	0.769
1991	0.649	10153	10.153	11.931	0.568
1992	0.910	10721	10.721	15.583	0.863
1993	0.505	10290	10.290	17.711	0.509
1994	0.328	7585	7.585	17.019	0.446
1995	0.504	4858	4.858	9.808	0.744
1996	0.654	4759	4.759	6.607	1.129
1997	1.003	5991	5.991	7.399	1.729
1998	0.772	7994	7.994	7.252	1.289
1999	1.532	5815	5.815	5.542	2.349
2000	0.844	5772	5.772	3.590	0.945
2001	2.448	6430	6.430	3.748	2.547
2002	1.855	5735	5.735	2.647	1.406
2003	2.197	6829	6.829	3.428	1.474
2004	1.925	7502	7.502	3.382	1.084
2005	2.533	9675	9.675	5.358	1.366
2006	0.959	7390	7.390	4.233	0.438
2007	0.754				

Table M5. AIM Results for Pollock in Subareas 5 and 6 under two formulations.

Commercial Landings Alone

Randomization Test Results

Index - 1 INDEX - 1

Critical Value = -5.281979E-001

Significance Level = 4.000000E-002

Simple Regression

Index - 1 INDEX - 1

$$\text{LN(Replacement Ratio)} = A + B * \text{LN(Relative F)}$$

Coefficient	A	B
Estimated Value	7.937413E-001	-4.590033E-001
Std Error Coefficient	2.493708E-001	1.213076E-001
t-Statistic	3.182975E+000	-3.783797E+000
p-Value (2 sided Test)	2.951840E-003	5.479548E-004
Variance Inflation Factor	9.029471E+000	1.000000E+000

$$\text{Relative F (for ln(Replacement Ratio) = 0)} = 5.636545E+000$$

Commercial and Recreational Landings

Randomization Test Results

Index - 1 INDEX - 1

Critical Value = -5.282129E-001

Significance Level = 4.000000E-002

Simple Regression

Index - 1 INDEX - 1

$$\text{LN(Replacement Ratio)} = A + B * \text{LN(Relative F)}$$

Coefficient	A	B
Estimated Value	8.069553E-001	-4.609407E-001
Std Error Coefficient	2.526576E-001	1.218148E-001
t-Statistic	3.193869E+000	-3.783945E+000
p-Value (2 sided Test)	2.866123E-003	5.477199E-004
Variance Inflation Factor	9.269261E+000	1.000000E+000

$$\text{Relative F (for ln(Replacement Ratio) = 0)} = 5.758462E+000$$

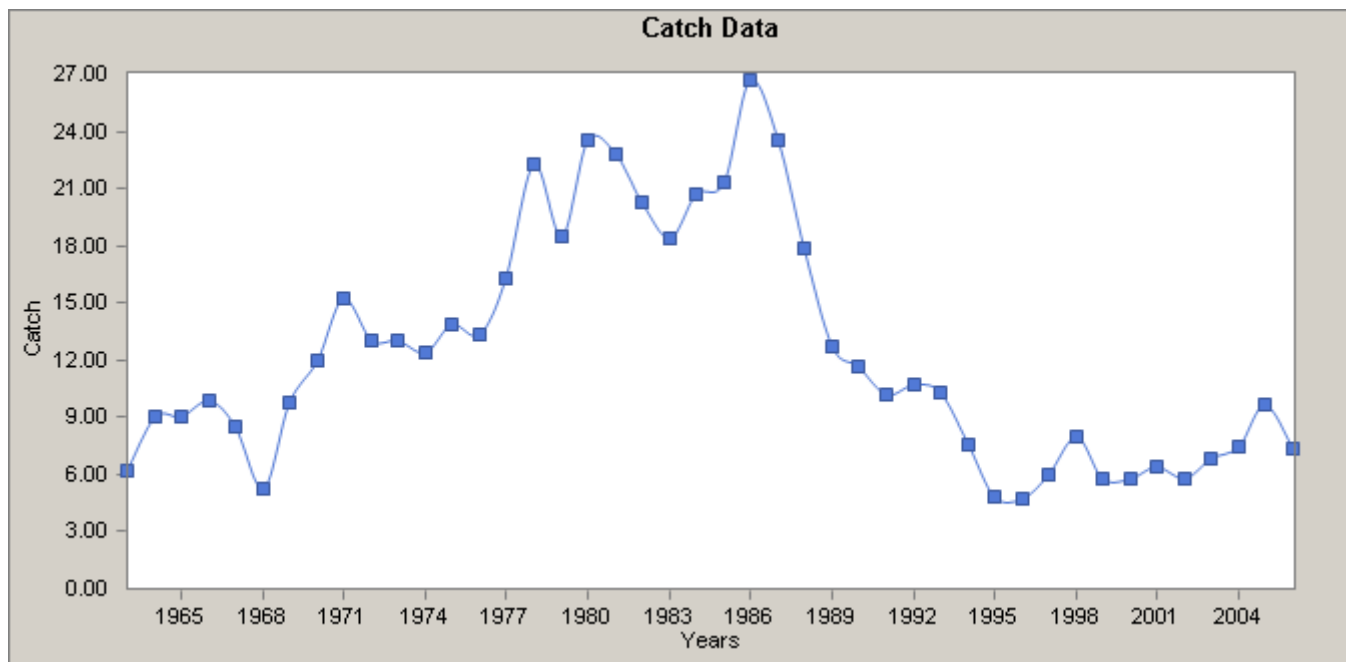


Figure M1. Total commercial and recreational landings (mt) of pollock from SA 5&6.

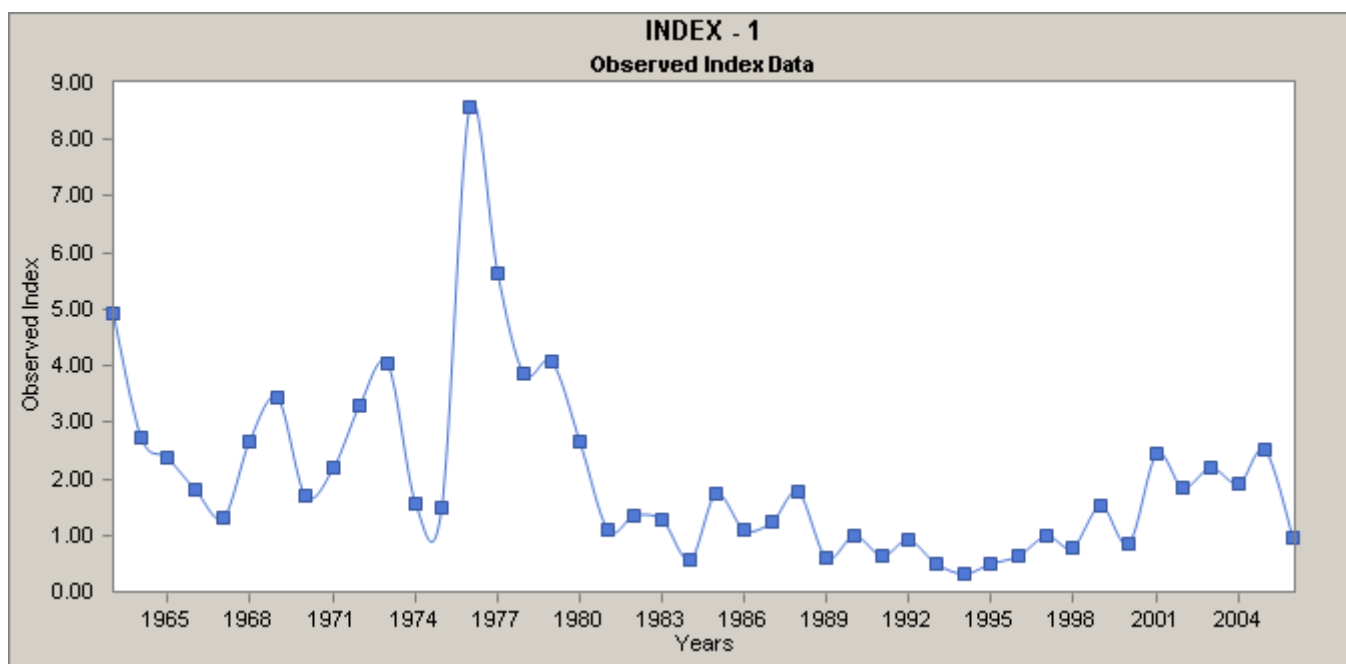


Figure M2. Log re-transformed biomass (stratified mean weight per tow [kg]) index for pollock from the NEFSC autumn bottom trawl surveys.

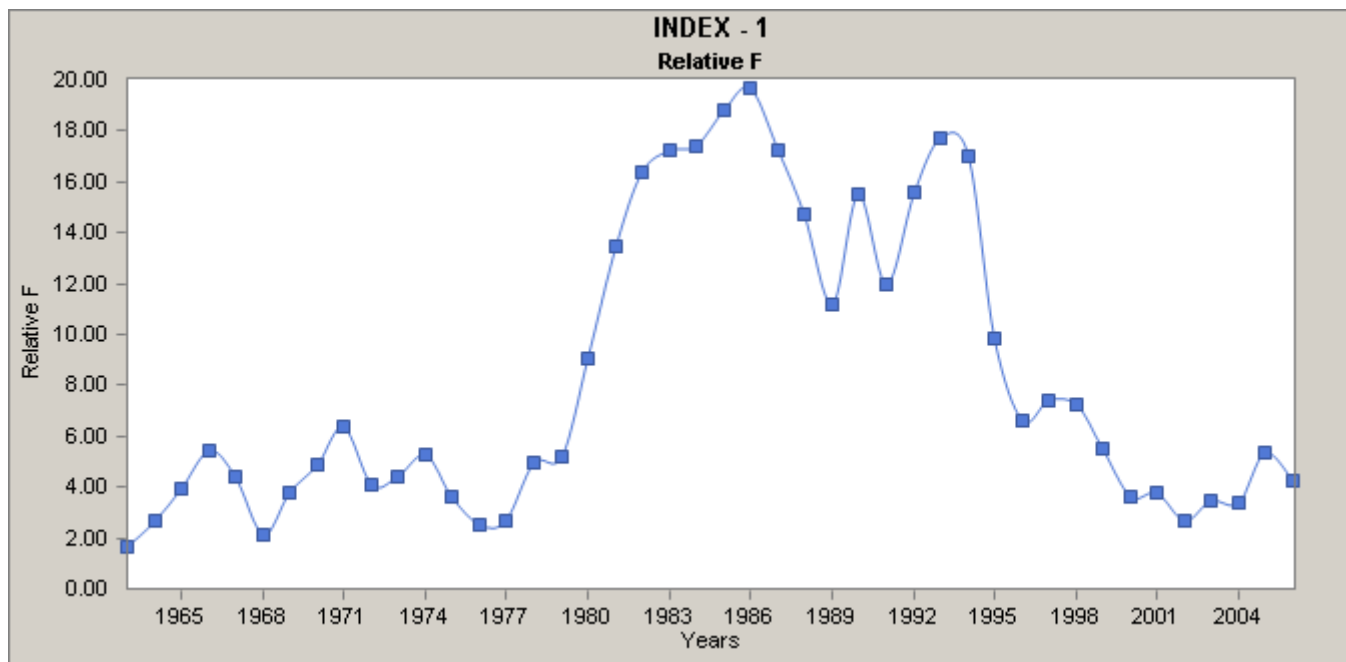


Figure M3. Relative F(commercial and recreational landings/biomass index) for pollock in SA 5&6.

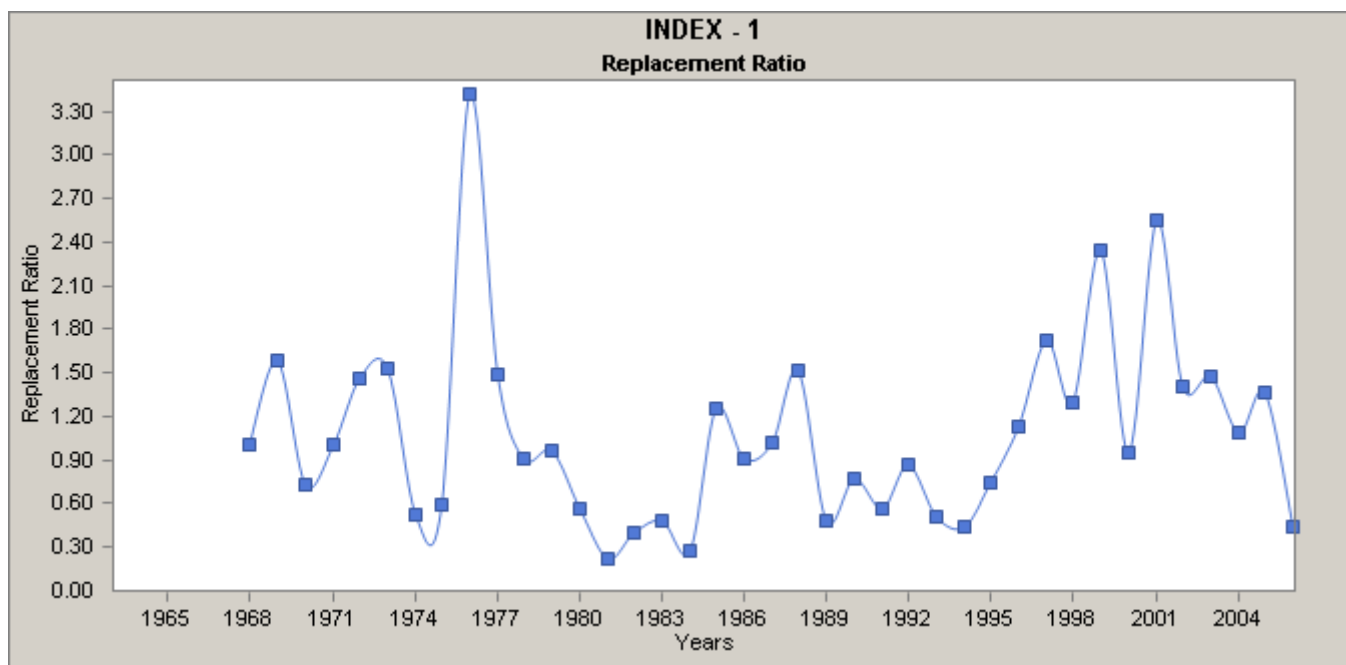
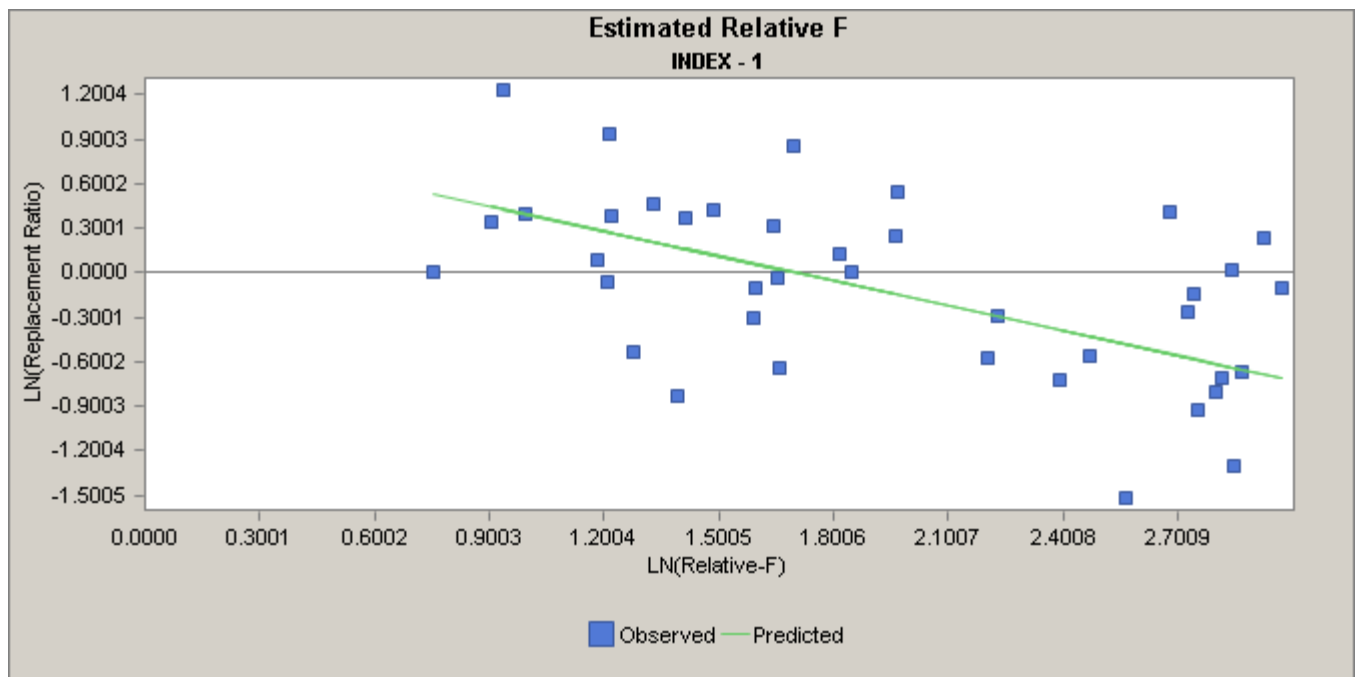


Figure M4. Replacement Ratios for pollock in SA 5&6.

Commercial Landings



Commercial and Recreational Landings

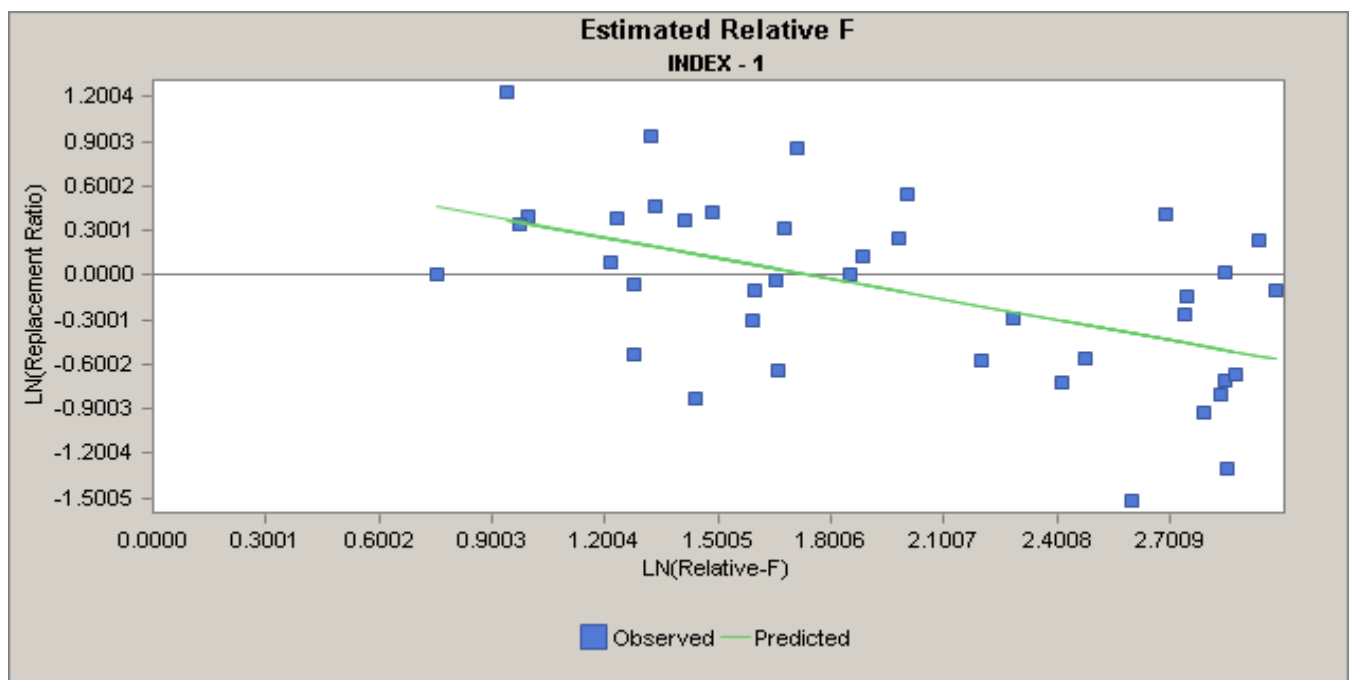
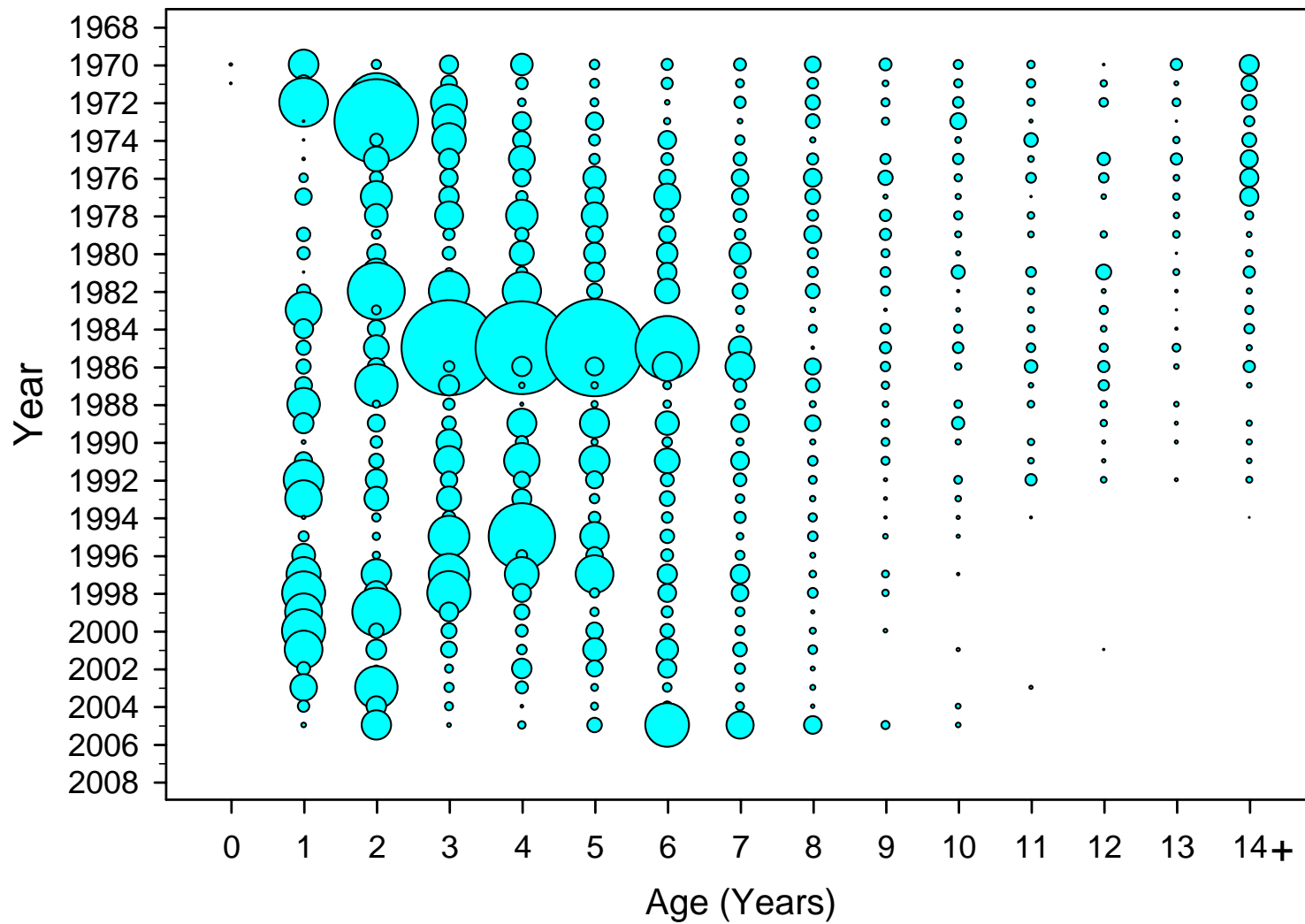


Figure M5. Estimates of Fmsy proxy values derived from AIM for pollock in SA 5&6

Spring	Linear			Pollock			Age			~lcol/survey/Pollock/polindices_agettr.xls					
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1970	0.0086	0.419	0.051	0.17	0.2345	0.0554	0.0732	0.0818	0.1324	0.0821	0.0499	0.0364	0.0063	0.0755	0.183
1971	0.0057	0.1366	0.1125	0.1291	0.0773	0.049	0.0727	0.0403	0.0666	0.0243	0.0412	0.0464	0.0277	0.0151	0.1287
1972	0	1.0853	1.5422	0.6085	0.0397	0.0418	0.0187	0.0722	0.1158	0.0431	0.0638	0.0352	0.0473	0.0385	0.1194
1973	0	0.0057	3.0894	0.5151	0.1722	0.1534	0.0274	0.0173	0.1053	0.0345	0.1306	0.0101	0	0.0055	0.0622
1974	0	0.006	0.0874	0.5265	0.1576	0.0686	0.1618	0.0528	0.0218	0	0.0245	0.1008	0	0.0299	0.1061
1975	0	0.0086	0.3018	0.2062	0.3276	0.0653	0.08	0.0918	0.0742	0.0606	0.0652	0.025	0.0855	0.0737	0.1555
1976	0	0.0466	0.0956	0.1571	0.1551	0.25	0.1355	0.1452	0.1677	0.1159	0.0355	0.0594	0.0535	0.0245	0.1699
1977	0	0.1419	0.4603	0.1975	0.0723	0.173	0.3276	0.1349	0.1201	0.0145	0.0214	0.0043	0.0194	0.0297	
1978	0	0	0.2605	0.3756	0.4696	0.3292	0.0923	0.0916	0.0668	0.0722	0.0423	0.0321	0	0.024	0.0414
1979	0	0.1025	0.0494	0.071	0.0971	0.1455	0.1447	0.0671	0.1508	0.0748	0.0268	0.0257	0.0288	0.0314	0.0202
1980	0	0.0861	0.171	0.0879	0.2841	0.2226	0.2145	0.2288	0.0616	0.044	0.0155	0	0	0.0044	0.0303
1981	0	0.0051	0.3445	0.0385	0.0664	0.1849	0.1772	0.0784	0.0615	0.0603	0.0975	0.06	0.1199	0.026	0.075
1982	0	0.0994	1.4502	0.7482	0.6801	0.1214	0.2943	0.1227	0.1082	0.0494	0.008	0.0277	0.0145	0.0082	0.0224
1983	0	0.6007	0.0497	0.0224	0.0205	0.0036	0	0.0416	0.0189	0.009	0.0139	0.025	0.0436	0.0055	0.0423
1984	0	0.1832	0.152	0.1206	0.1092	0.1498	0.0759	0.0332	0.0383	0.0585	0.0409	0.0336	0.0247	0.0075	0.0565
1985	0	0.1113	0.2993	3.9476	3.7598	4.1374	1.7813	0.2464	0.0086	0.0747	0.0675	0.0479	0.0443	0.0393	0.0214
1986	0	0.1141	0.1494	0.0656	0.1902	0.1682	0.4018	0.4063	0.1379	0.0553	0.0302	0.09	0.0713	0.0196	0.073
1987	0	0.1469	0.8294	0.2079	0.0235	0.0325	0.0383	0.0956	0.1037	0.0375	0	0.0189	0.0639	0	0.0178
1988	0	0.4955	0.0356	0.0734	0.0117	0.0291	0.0374	0.0592	0.0263	0.0228	0.0376	0.0318	0.0286	0.018	0
1989	0	0.2045	0.152	0.1025	0.3948	0.3992	0.2716	0.1581	0.1302	0.0368	0.0862	0	0.0281	0.0112	0.0223
1990	0	0.0142	0.0763	0.3089	0.0837	0.0298	0.0568	0.0358	0.0222	0.0398	0.0213	0.0274	0.0116	0.0104	0.0221
1991	0	0.1547	0.1075	0.4132	0.5857	0.4284	0.2992	0.1614	0.0541	0.0411	0	0.0253	0.0129	0	0.0196
1992	0	0.7278	0.2214	0.1416	0.1389	0.1529	0.0917	0.0898	0.0385	0.0119	0.0385	0.0719	0.0242	0.0121	0.0262
1993	0	0.6247	0.2723	0.2922	0.1835	0.0556	0.1169	0.0468	0.0232	0.0098	0.0232	0	0	0	0
1994	0	0.0125	0.0447	0.0912	0.1226	0.0765	0.0665	0.0738	0.0447	0.0077	0.0113	0.0068	0	0	0.0032
1995	0	0.0627	0.0349	0.7764	1.9524	0.3867	0.1025	0.0311	0.054	0.0195	0.0113	0	0	0	0
1996	0	0.2516	0.0352	0.0052	0.0648	0.1416	0.0823	0.0492	0.0199	0	0	0	0	0	0
1997	0	0.5384	0.4224	0.7541	0.5494	0.6651	0.1879	0.1783	0.0323	0.0336	0.0075	0	0	0	0
1998	0	0.8484	0.2697	0.866	0.1725	0.053	0.1625	0.1477	0.0584	0.0305	0	0	0	0	0
1999	0	0.6332	1.0499	0.1803	0.123	0.0449	0.0736	0.0488	0.0116	0	0	0	0	0	0
2000	0	0.8535	0.1098	0.1216	0.0805	0.1425	0.1024	0.0511	0.0262	0.0142	0	0	0	0	0
2001	0	0.6668	0.2016	0.1326	0.0562	0.2597	0.2333	0.1048	0.0466	0	0.0118	0	0.005	0	0
2002	0	0.0934	0.0265	0.0427	0.1979	0.1349	0.1697	0.0613	0.0152	0	0	0	0	0	0
2003	0	0.3387	0.8167	0.0527	0.0826	0.0341	0.0474	0.0408	0.0208	0	0	0.0121	0	0	0
2004	0	0.0772	0.1962	0.0426	0.0085	0.0358	0.0578	0.0424	0.0128	0	0.0209	0	0	0	0
2005	0	0.0174	0.4148	0.0142	0.0371	0.1133	0.8795	0.3521	0.1578	0.0428	0.0173	0	0	0	0

Autumn	Linear	Pollock					Age		~lcol/survey/Pollock/polindices_ager.xls						
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1970	0.006	0.131	0.0883	0.0071	0.0991	0.0934	0.0678	0.032	0.0232	0.0179	0.0113	0.006	0	0.0158	0.0099
1971	0.0247	0.1308	0.4066	0.1537	0.0389	0.0597	0.0986	0.0346	0.0947	0.0305	0.0288	0.0074	0.0088	0.0081	0.0744
1972	0	0.3839	0.2812	0.2119	0.0683	0.0773	0.0834	0.0757	0.0697	0.053	0.0229	0.0312	0.0208	0.0299	0.0392
1973	0	0.0276	0.3318	0.1073	0.1711	0.0916	0.12	0.0829	0.0792	0	0.1316	0.0168	0.0078	0.0401	0.0592
1974	0	0.0029	0.0857	0.2918	0.226	0.0864	0.1017	0.1011	0.0058	0.0144	0	0.0203	0	0	0.0171
1975	0.0135	0.2487	0.0321	0.0437	0.1051	0.0732	0.0576	0.0571	0.0155	0.0272	0.0254	0.0051	0	0.0025	0.0115
1976	0	0.0377	0.0267	0.1149	0.5738	1.8192	0.616	0.3119	0.174	0.0452	0.0096	0.0051	0.026	0.0568	0.2211
1977	0	0.0668	0.1853	0.2615	0.3053	0.4529	0.4017	0.1882	0.1132	0.1056	0.0328	0	0.0267	0.0105	0.1213
1978	0.0096	0.0316	0.2118	0.0432	0.0457	0.1104	0.0897	0.1592	0.0768	0.0685	0.0416	0.0323	0.0219	0.0293	0.0921
1979	0.0025	0.0095	0.0228	0.1713	0.1442	0.0861	0.0949	0.0771	0.0828	0.0599	0.0389	0.0121	0.0119	0.0174	0.0336
1980	0	0.0766	0.012	0.009	0.0515	0.1063	0.0368	0.0371	0.0768	0.0439	0.0503	0.0257	0.0038	0.0147	0.0362
1981	0	0.0081	0.1607	0.5275	0.0722	0.1283	0.0426	0.0495	0.0013	0.0006	0	0	0.0057	0.0143	0.0226
1982	0.0057	0.0783	0.2017	0.1965	0.0562	0.0206	0.0527	0.0499	0.0085	0.0216	0.0025	0.025	0.0023	0.0023	0.0347
1983	0	0.5078	0.0281	0.0527	0.0456	0.0604	0.0164	0.0533	0.0722	0.0323	0.0164	0.0229	0.022	0.0228	0.0228
1984	0	0.0363	0.1424	0.0276	0.0066	0.1443	0.1588	0.0612	0	0.1766	0.1081	0.0469	0	0	0
1985	0	0.6378	0.0573	0.0957	0.0753	0.0874	0.0589	0.0242	0	0	0.0028	0.0013	0	0.0192	0.0197
1986	0	0.221	0.2236	0.1494	0.1524	0.0579	0.0379	0.0285	0	0	0	0.0193	0.0082	0	0
1987	0	0.039	0.21	0.0602	0	0.0605	0.0214	0.0869	0.0422	0.0494	0	0.0082	0.0113	0	0.0082
1988	0	0.1193	0.1131	1.084	1.4345	0.2868	0.4487	0.0976	0.1058	0.0057	0.0234	0.0162	0.0033	0.006	0.01
1989	0.3121	0.3775	0.6935	0.321	0.1148	0.0113	0	0	0.0164	0	0.0098	0.0118	0.0098	0.005	0
1990	0.07	0.0254	0.1271	0.2151	0.1396	0.0915	0.0239	0.0262	0.0226	0.0227	0.0192	0.0101	0.005	0.005	0.0192
1991	0.0036	0.1228	0.1255	0.1365	0.2313	0.0574	0.0397	0.0113	0	0	0	0	0	0	0
1992	0.024	0.2958	0.2318	0.1198	0.1486	0.1496	0.0395	0.0175	0.0243	0	0	0	0	0	0
1993	0	0.4554	0.3943	0.0811	0.0313	0.0166	0.0505	0	0	0	0	0	0.0071	0	0.0071
1994	0	0.0094	0.0727	0.1643	0.1003	0.0589	0.0163	0	0	0	0	0	0	0	0
1995	0.0041	0.0305	0.1655	0.4329	0.1141	0.0643	0.0288	0	0	0	0	0	0	0	0
1996	0	0.3433	0.2826	0.0371	0.2063	0.1104	0.0237	0.0057	0	0	0	0	0	0	0
1997	0	0.6759	0.5626	0.1475	0.1775	0.1723	0.0306	0	0	0	0	0	0	0	0
1998	0.0076	1.2064	0.3386	0.3354	0.1161	0.0468	0.0326	0.0199	0	0	0	0	0	0	0
1999	0.07	0.6034	0.5628	0.2154	0.4835	0.2453	0.1825	0.0382	0.0126	0	0	0	0	0	0
2000	0.0041	0.8003	1.8248	0.0811	0.0187	0.0247	0.0162	0	0	0	0	0	0	0	0
2001	0.0325	0.1249	0.5812	0.4545	0.4854	0.219	0.1244	0.0497	0.0118	0	0.0099	0	0	0	0
2002	0	0.236	0.1753	0.8632	0.6586	0.7452	0.3193	0.0711	0	0	0	0	0	0	0
2003	0.2231	0.2901	1.9049	1.3269	3.0857	0.5745	0.0675	0	0	0	0	0	0	0	0
2004	0	0.1545	0.4166	1.6252	0.3926	0.3879	0.1828	0.0797	0	0	0	0	0	0	0
2005	0.0349	0.04	2.095	0.3912	0.8209	0.6295	0.6874	0.1076	0.0113	0	0	0	0	0	0

Pollock Number at Age Indices from NEFSC Spring Survey



Pollock Number at Age Indices from NEFSC Autumn Survey

